Increased Photosynthetic Performance of *Brassica napus* Contributes to Enhanced Cd Phytomanagement under Warmer Climate Despite Drought Stress

A. Dikšaitytė[1], J. Žaltauskaitė[1], I. Kniuipytė[2], and R. Juknys[1]

[1]Department of Environmental Sciences, Vytautas Magnus University, Universiteto st. 10, Akademija, Kaunas distr., LT-53361, Lithuania

[2]Lithuanian Energy Institute, Laboratory of Heat-Equipment Research and Testing, Breslaujos st. 3, Kaunas, LT-44403, Lithuania

Presenting author e-mail: austra.diksaityte@vdu.lt

Introduction

- The world growing population with the increased anthropogenic activities such as disposal of manure, wastewater and sewage sludge, indiscriminate use of phosphate fertilizers and pesticides has resulted in widespread contamination of cadmium (Cd) and other heavy metals (HMs) in the environment.
- Phytoextraction, a plant-based technique where plants are used to translocate HMs from the soil into aboveground harvestable biomass, has been considered to be among the safest, cleanest, cost-effective, and sustainable options for treating sites contaminated with recalcitrant pollutants like HMs.
- However, the ongoing climate change with the increased drought periods is bound to have an impact on phytoextraction performance, yet there remains little research on this.
- The **aim** of this study was to **investigate Cd phytoextraction efficiency** by ***Brassica napus*** under **drought stress** in **current** and **future warmer climate** conditions.

Materials and Methods

The **pot experiment** with ***B. napus*** was conducted in the growth chambers under a controlled environment for a period of **64 days**.

The experiment was carried out in a **completely random design** using **tree factors**: **Cd, climate,** and **drought.**

Cd concentrations: 0 (control), 1, 10, 50, 100 mg Cd kg^{-1} (as $CdCl_2 \times 2.5\ H_2O$) in soil.

Climate conditions: future warmer climate (**FWC: 25/18 °**C, day/night, **800** ppm CO_2, 45-50/55-60% RH) *vs.* current climate (**CC: 21/14** °C, **400** ppm CO_2, 55-60/65-70% RH).

Drought stress: withholding watering on the **46th day** after sowing until **5%** of **SWC** till the end of the experiment *vs.* **30%** of **SWC** for well-watered plants.

Duration of Cd treatment from thinning plants to seven units in a pot – **43 days**, **duration of drought stress** at **5% SWC** – **12 days**.

Cd concentrations in mineralized samples were determined by **ICP-OES** method.

Cd removal efficiency, defined as **Cd accumulation**, was determined by the harvestable plant biomass multiplied by the concentration of Cd contained within this biomass.

Photosynthetic performance was evaluated using **gas exchange** (measured with LI-6400) and **chlorophyll fluorescence** (taken with a Handy PEA) parameters.

Results & Discussion

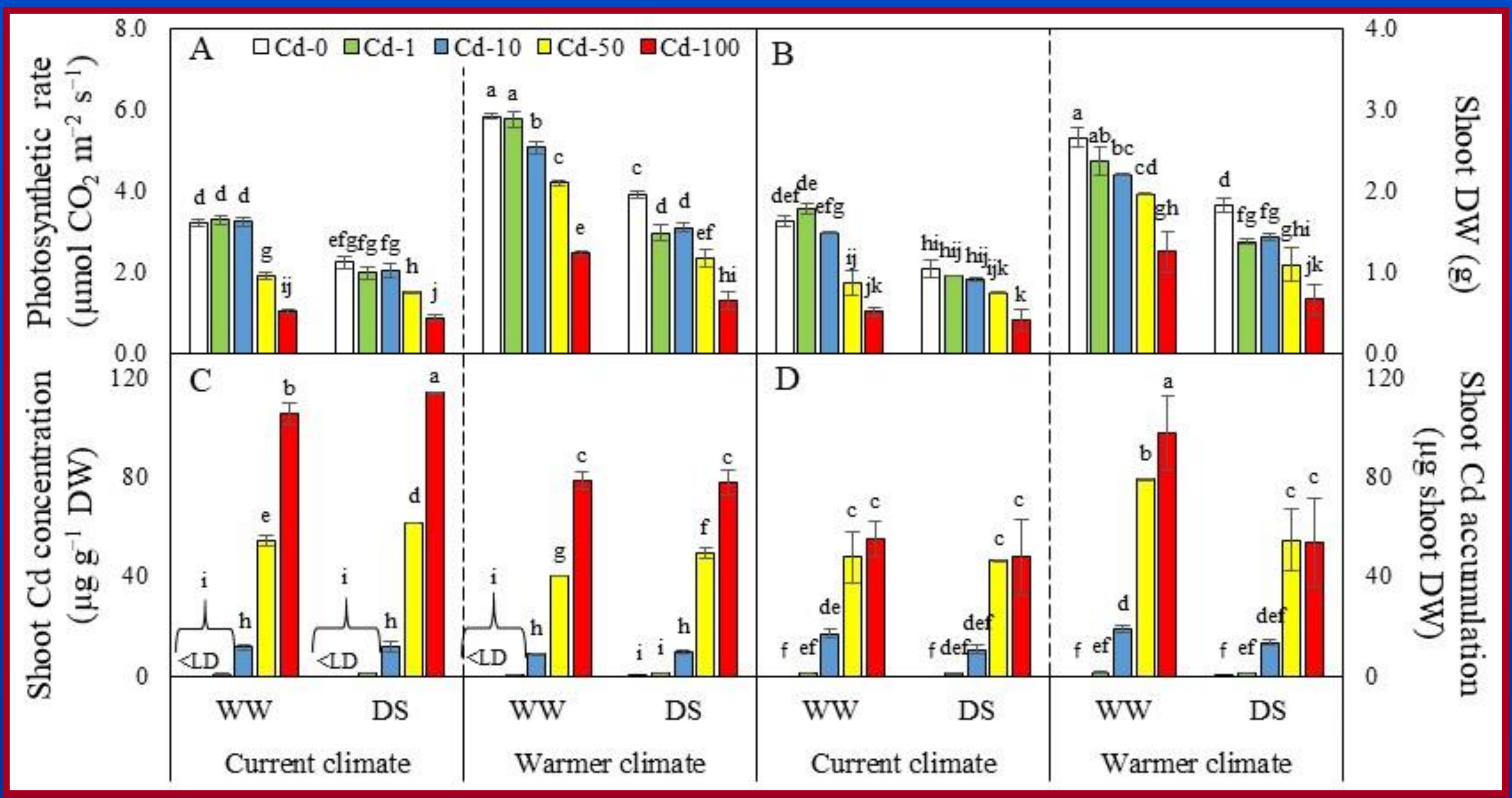

Figure 1. (A) Photosynthetic rate, (B) shoot DW, (C) shoot Cd concentration, and (D) shoot Cd accumulation of well-watered (WW) and drought-stressed (DS) *B. napus* plants grown under different Cd concentrations (0, 1, 10, 50, and 100 mg Cd kg^{-1}) in current and warmer climate conditions. Data are means ± SE (for photosynthetic rate n = 6-9, for other parameters n = 3); different letters outside the bars indicate significant differences among the treatments ($p < 0.05$, Fisher's LSD). <LD – below detection limit

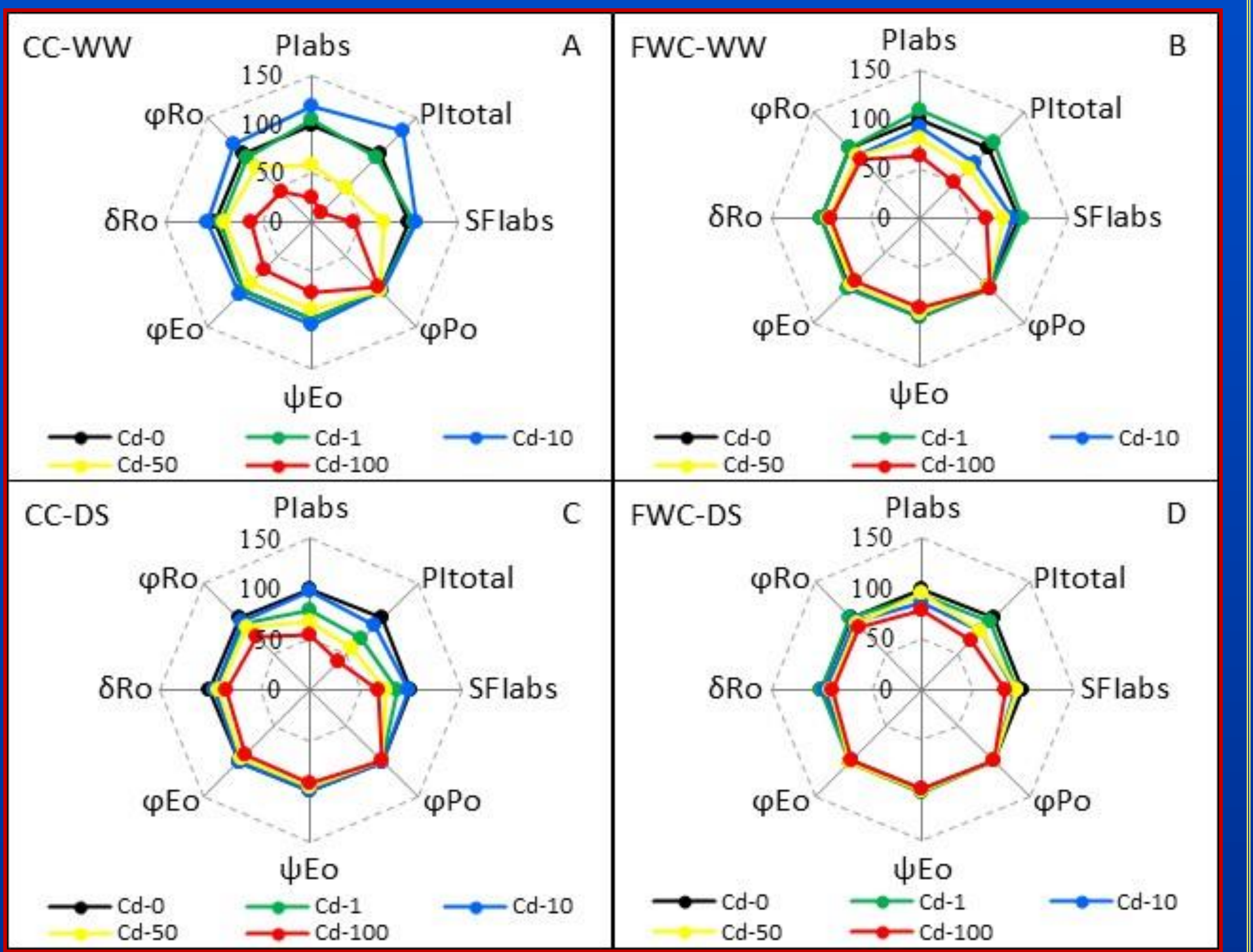

Fig. 2. Performance indexes on an absorption basis (PIabs, PItotal, and SFIabs) and quantum yields and efficiencies for photochemistry (φPo, ψEo, φEo, δRo, and φRo) normalized on radar plots. A and B: the effects of Cd on well-watered *B. napus* plants in CC and FC conditions, respectively; C and D: the effects of Cd on drought-stressed *B. napus* plants in CC and FC conditions, respectively. Each curve represents the average of 3 measurements per treatment. Under both climate and water conditions, the status of Cd-stressed rape (Cd-1, Cd-10, Cd-50, and Cd-100) is shown relative to the status of control, i.e., Cd-untreated ones (Cd-0), expressed as 100% (*black line*).

- Under both water regimes, in higher Cd treatments (50 and 100 mg Cd kg^{-1}), FWC conditions resulted in lower Cd concentration in *B. napus* shoot DW when compared to those grown under CC conditions ($p < 0.05$) (Fig. 1C).
- Under both water regimes, FWC conditions resulted in better photosynthetic performance of *B. napus* in response to Cd stress (Fig. 2), allowing them to significantly increase their photosynthetic rate (Fig. 1A), which translated into higher aboveground biomass production (Fig. 1B).
- The latter fact led to highly increased (up to 65-76%, $p < 0.05$) Cd accumulation in the aboveground biomass of well-watered *B. napus* plants grown in higher Cd treatments (50 and 100 mg Cd kg^{-1}) under FWC conditions (Fig 1D).
- Drought-stressed plants of *B. napus* grown under FWC conditions did not extract significantly higher Cd content, compared to those under CC conditions, however, the accumulated Cd content in their shoot DW did not differ significantly from well-watered ones grown under CC conditions (Fig. 1D).

Conclusions

The findings of this study revealed that *B. napus* has the potential to be more efficient for Cd phytomanagement purposes at higher Cd levels in soil under future warmer climate conditions, even in the presence of drought stress.

Acknowledgements

This research is funded by the European Social Fund under the No 09.3.3-LMT-K-712 "Development of Competences of Scientists, other Researchers and Students through Practical Research Activities" measure.

2014-2020 Operational Programme for the European Union Funds Investments in Lithuania